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Automated Generalization of Road Networks for Topographic Base Map

Nguyen Thi Hong Hanh[1], Cuong Vu Xuan[2], and Nguyen Ngoc Thy[1]

1. Faculty of Land Management and Real Estate, HCMC Nong Lam University, Vietnam

2. University of Natural Resources and Environment, Ho Chi Minh City, Vietnam

Abstract: Automated generalization is a very challenging problem for map producers and plays an important role in map creation. Road networks are important features on topographic base maps. They are sensitive to scale change, therefore multiple representations are required to maintain visual and geographic logic at smaller scales. This paper focuses on the characteristics, hierachies, constraint parameters and automated generalization of the road features on the topographic base map at different scales. The generalization steps were implemented in ArcGIS Model Builder using mentioned out-of-the-box functionality, which removes features by feature hierarchy and network connectivity, yet preserves characteristic urban local density patterns that can be lost through simple category removals. The tool and constraint parameters are used to automatically generalize road networks from maps scale of 1: 2,000 to scales of 1:10,000 area of Ho Chi Minh City, Viet Nam. Research result shows that using reasonable parameters and tools could provide a good way to generalize and create base map layers meeting different demands and building multi-purpose map database in the future.

Key words: GIS, map generalization, topographic base map, road network, automated generalization

1. Introduction

Map generalization is a special method to choose and generalize the map content elements, clarifying and indicating on map the specific characteristics, the basic and typical features of the object, the phenomena and the relationship, highlighting the natural and socio-economic developed rules. Generalizing plays a very important role in the mapping process and it remains one of the challenging issues nowadays especially for supporting the process of creating base maps for building thematic maps. Generalization in cartography is the simplification and clarification of features to improve display at smaller scales. cultivation, especially in the coastal low-lying areas of the Mekong River Delta. Saltwater intrusion can also be worsened by extreme events like hurricane storm surges.

Generalization of road features is very important because lines represent the majority of map features. An automated method is presented for the generalization of linear features that are already in a topologically structured computer-readable form [1]. One of the most popular is the toolset in ESRI's ArcGIS software. These tools provide certain utilities for map edition and also provide the flexibility of using different approaches for map generalization [2]. Road generalization includes Road Modeler, which converts original road edges to road polygons, and Network Generator, which collapses road polygons to road networks. The created network is topologically connected and suitable for GIS (Geographical Information System), such as car navigation systems [3]. Recent road generalization work within the scale range of 1:24,000 (24 K) to 1:1,000,000 (1 M) indicates that midrange scales are particularly difficult to represent through common display-based strategies, which eliminate road categories and use simpler,

Corresponding author: Nguyen Thi Hong Hanh, E-mail: honghanh@hcmuaf.edu.vn.

thinner line symbols for road representations [4]. This paper presents a general goal of fully automated and database-driven multiscale cartography; it is not an option for USGS cartographers to hand-select a few streets that run through the middle of each town to improve each of their maps, when the challenge is to map the whole country with limited staff and continual updates to national databases. Methods to thin road networks have been developed to support cartographic generalization, and research continues to refine these methods.

Automated thinning of road networks and road labels for multiscale design of The National Map of the United States. This paper reports on progress in generalization and selective feature removal for a subset of fundamental base map layers that enables competent mapping through scales ranging from 1:24,000 to 1:1,000,000. Thinning and partitioning methods are applied to road features and labels for The National Map of the United States.

Roads are major features in a map, and most efforts about automatic generalization have been made in line's generalization or simplification. Furthermore, roads are the most basic objects in a digital map. Many studies present methods to automatically generalize roads and buildings. With the proposed method, road generalization and building generalization are carried out consecutively.

In fact, each field needs geographic database with different levels of detail. The applications of geographic database that associated with GIS applications in reality meet certain difficulties [4]. Topographic basemaps in the geographic database are usually stored in multi-scale form, but data at different scales are not harmoniously combined, asynchronous, and updated simultaneously.

2. Data and Methodology

2.1 Data

Map data source is road layers on topographic base maps at scale 1:2000 in Ho Chi Minh City, Vietnam. Main data source is topographic maps at scale 1:2000, which are in VN-2000 datum. These data had been processed with Microstation software to be suitable for further map generalization procedure (Fig. 1).

C-48-34-(51-a)
C-48-34-(51-d)
C-48-34-(51-g)
C-48-34-(51-b)
C-48-34-(51-e)
C-48-34-(51-h)
C-48-34-(51-c)
C-48-34-(51-f)
C-48-34-(51-k)

Fig. 1 Road features on maps at the scale of 1:2,000.

These data had been processed with Microstation software to be suitable for further map generalization procedure. But there are many mapping errors as classifying contents, errors in graphics ....So to use this map system, we use Microstation software in revising, editing, finishing data and content classification suitable to the mapping generalized objective.

Based on defined generalization constraint parameters, cartographic generalization processes are implemented. Defined processes are performed by generalization toolset in ArcGIS, with data in HCMC (roads data layers) for verifying.

2.2 Methodology

Research and identify constraint parameters:

For creating multi-scale base maps (1:2,000-1:10,000) from original data maps at scale of 1:2,000, the constraints, specifications, standards for generalization have to be identified at each scale level. These parameters re determined, based on cartographer's experiences, constraints-specifications, standards of symbols, visual assessment of the results on screen and prints, references to minimum sizes, distribution and density on mapping space, control of generalization process through appropriate tolerances/parameters.

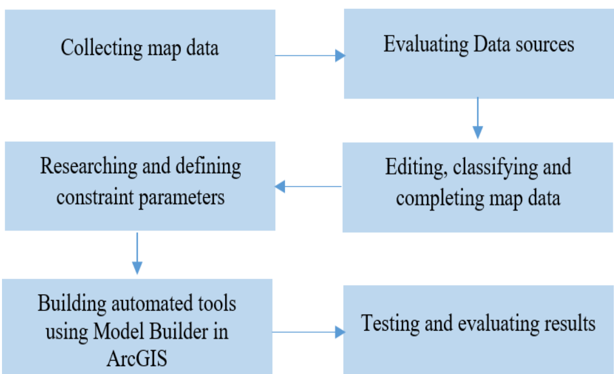

Fig. 2 Methodology used in map generalization.

3. Results and Discussion

3.1 The Road Generalization Constraint Parameters

The popular simplifying line algorithm is Douglas-Peucker. This algorithm is then be used to developetwo the algorithms POINT_REMOVE and BEND_SIMPLIFY. BEND_SIMPLIFY Obtained results keep the original shape with geometric quality better than Point remove, however, this process takes more time. Base on map generalization algorithms and practical experiences we can define road generalization constraint parameters as in Table 1.

Table 1 Road generalization constraint parameters.

Constraint parameters	The corresponding size in reality		
Constraint parameters	**1:2,000**	**1:5,000**	**1:10,000**
Minimal length of a object (m)	20	50	100
Minimal tolerance (m)	1.0	2.5	5.0
Width of two-way (m)	1.6	4.0	8.0
Width of one-way (m)	1.2	3.0	6.0

There are a number of parameters that could be used for generalization of roads to maintain the legibility, the visual identity of each road segment and the pattern.

3.2 Hierarchy of Road Network on Topographic Base Map

Data source databases that are used in this research is provided by national mapping agency, ministry of natural resources and environment. The roads may be classified, e.g., by importance or by administrative rules (national road classification), the type of road, the covered surface material. However, if using this data source with available classification to generalize the map, the results show that there are many conflicts on the target map and automatically generalization the data layer from one scale to another has many difficulties and complex. Manual editing was still required after the generalization. Furthermore, each of the software has tools suited for specific situations and feature classes work best in terms of types of features class. Thus, to be convenient in the shown process on the multi-scale maps and not to conflict with the essential other factors, we reclassify according to the private layers and may give the generalized behaviour in that layer.

A good classification of roads makes the selection easier and more accurate. This step identifies objects that are placed in groups according to similar properties. It also reduces the complexity and will improve the quality of map generalization.

Roads have varying widths and types. These are Dual road, principal road, secondary road, minor road, and vehicle track…By Using available tools in ESRI

ArcGIS software, the process of generalization, research experiences, and map regulations to create a new classification model of road data on a basemap below (Fig. 3).

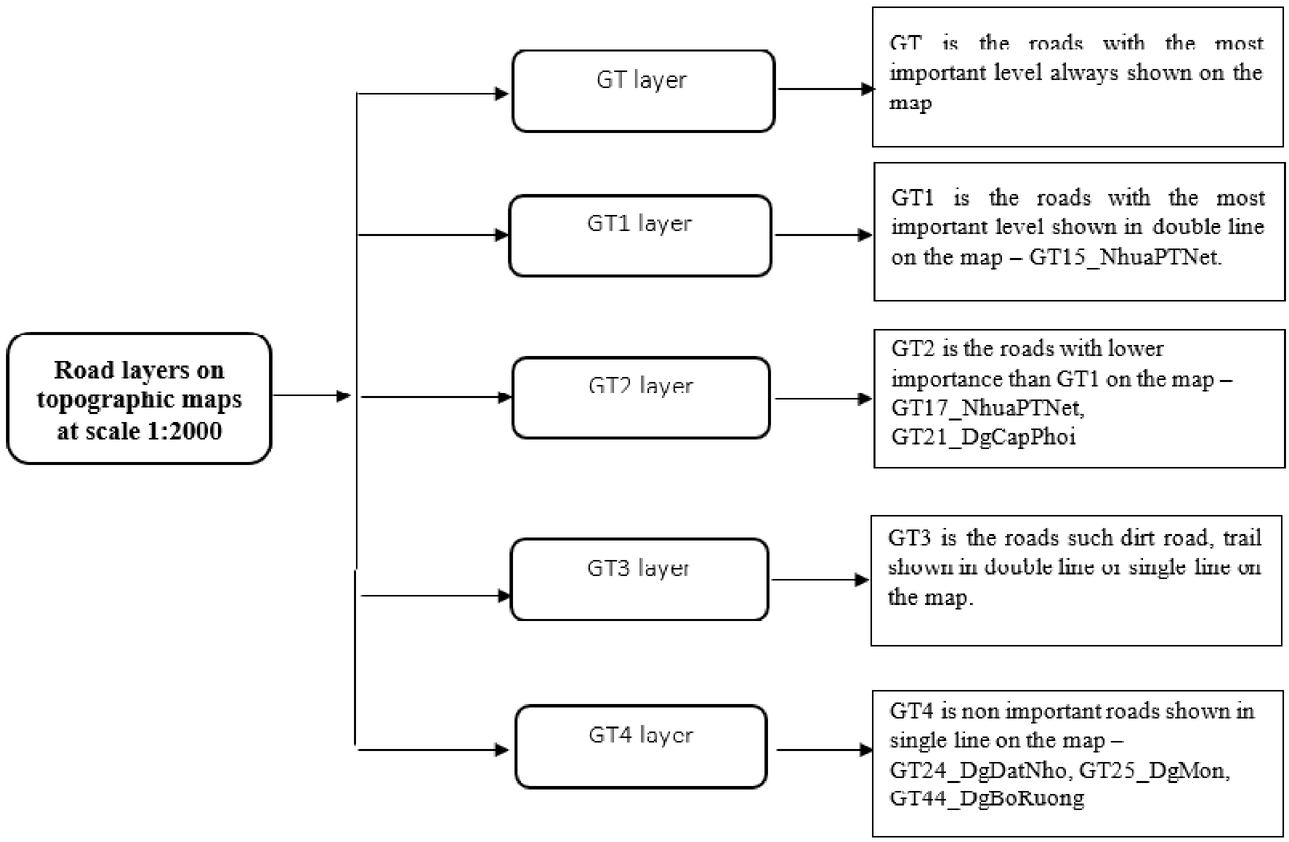

Fig. 3 Roads Classification on source maps.

3.3 Proposed Road Component Generalization for Topographic Base Map on a Scale of 1:10,000

There are approaches that usually used for constructing a generalization. Generalization tools can be applied to an entire feature class or only for selected objects and can also be combined to achieve the results needed. Based on classification of roads and experimental tests in our research process, we proposed road component generalization as in Fig. 4.

3.4 Testing and Evaluating of the Generalization Result

3.4.1 Automated Generalization of Road Data Layer (GT1)

According to the table of road generalization constraint parameters shown in Fig. 4, the width of the GT15_NhuaPTNet class is smaller than the constraint parameters (minimal length of an object), the road remains the same, preserving the visualization should be kept as dual line (or double line). GT15_NhuaPTNet, there is no change in shape.

3.4.2 Automated Generalization of Road Data Layer (GT2)

When generalizing two-way roads from 1:2000 to 1:10000, the resulting road is not represented by a dual line due to its narrow width, the result is not visual onscreen and prints. Therefore, the generalization collapse dual lines to centerline derives centerlines from dual-line (or double-line) features, based on specified width tolerances. If the width of roads is smaller than 6 m, collapse dual lines to centerline and keep as dual line if it is more than 6 m according to the map scale.

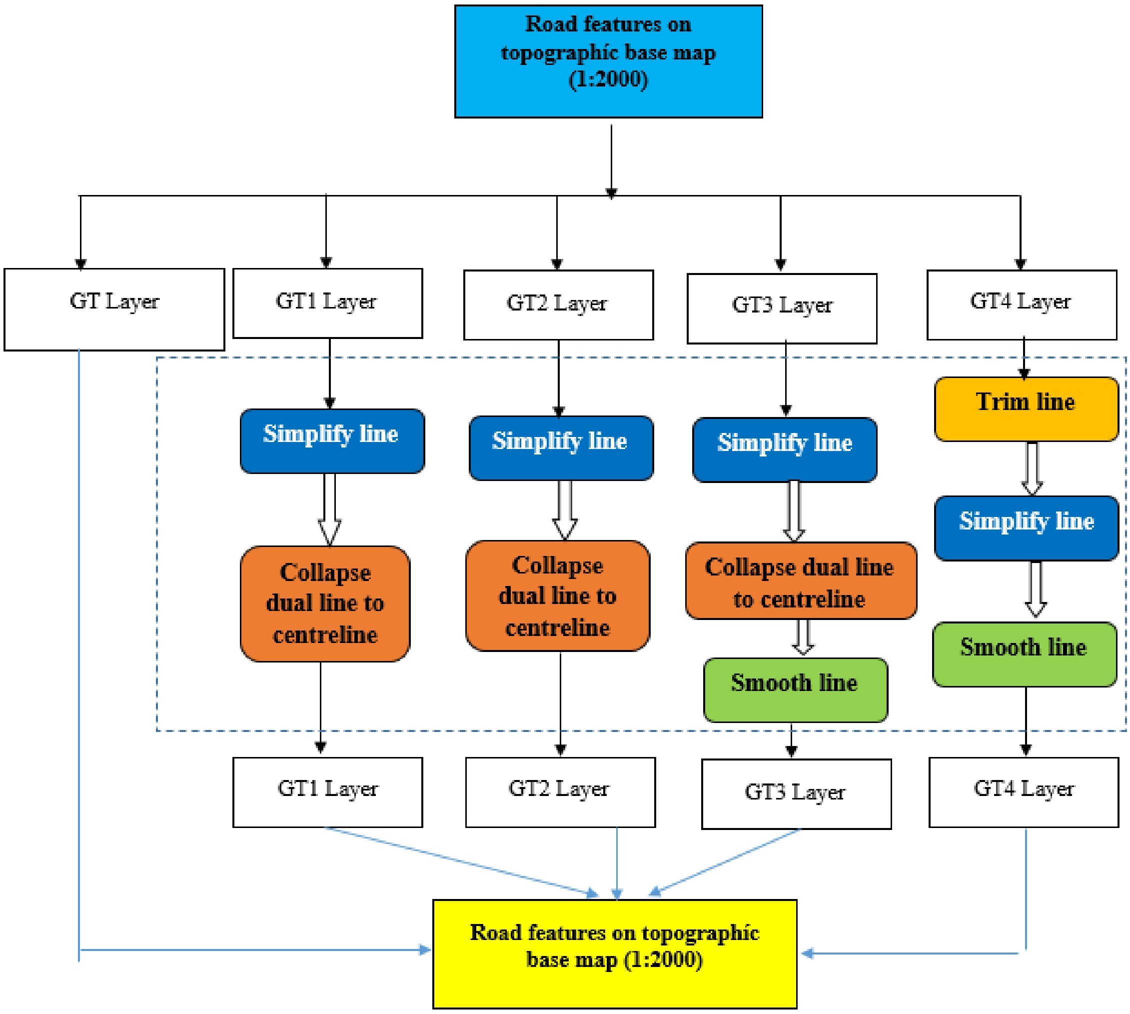

Fig. 4 Automated generalization of road networks in ArcGIS.

3.4.3 Automated Generalization of Road Data Layer (GT3)

Pathway is shown in double-line on the original map (1:2000). When automated generalization of road data layer (GT3), they are selected by length and density, then simplified and converted from dual-line to single line. Inaddition to, roads need to be smooth by line simplification algorithms on target map (1:10 000).

3.4.4 Automated Generalization of Road Data Layer (GT4)

According to the class model shown in Fig. 5, roads (GT4) are the least important objects, such as dirt roads, trails ... which have lower economic significance. So, when generalizing at a smaller scale, so they are eliminated by the criterion of length and the road bends are simplified to increase the visibility of the target map.

Fig. 5 Road network at scale 1:10,000.

4. Conclusions

Road features on the map are linear objects, when present on the map in scale, a set of road segments consecutively connected. Therefore, in addition to studying the criteria, a more important issue is the good classification of roads makes the generalization easier and more accurate.

There may be roads of very large length and width that are still removed on the map. However if the average segment length of a street is less than a given threshold that connected to major roads remain on the map. Other road features will be deleted and they include culverts, ditches, piers, any non important details in the smaller scales of 1:10 000. A road branch shorter than a certain length can be eliminated. Therefore, before generalizing, it is necessary to classify data properly to facilitate the use of generalization tools. The classification is based on geometric and semantic properties of the objects.

Based on the available toolset in ArcGIS 10 software, contraint parameters and road classification, we have automatically generalize road networks from maps scale of 1:2000 area of Ho Chi Minh City, working with groups of features contextually to create maps data at smaller scale (1:10 000). The results of target maps are reasonable, and afford the requirements contours in the months on the map.

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